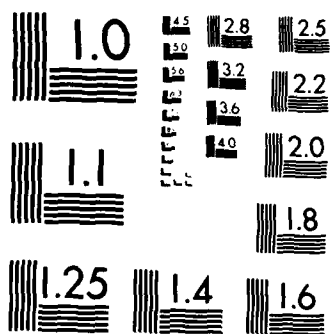


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CONTRACTOR REPORT ARLCD-CR-85002

**PRODUCT IMPROVEMENT PROGRAM FOR THE M577
FUZE--VOLUME 5, COMBINED
SAFE SEPARATION DEVICE (SSD) SPACER AND PLATE**

**TERRY F. SLAGLE
A. LUCILLE MEISSNER
HAMILTON TECHNOLOGY, INC.
P.O. BOX 4787
LANCASTER, PA 17604**

**THOMAS W. PERKINS, PROJECT ENGINEER
EDWINA CHESKY, PROJECT LEADER
ARDC**

MARCH 1985

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**U.S. ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER
LARGE CALIBER WEAPON SYSTEMS LABORATORY
DOVER, NEW JERSEY**

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The objective of this task was to develop a combined safe separation device (SSD) spacer and plate. The proposed design combines the SSD top plate, spacer, and rotor shaft into a zinc die cast part. The projected cost savings is \$0.167 per fuze not including tooling, general and administrative expenses, and profits.		

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INTRODUCTION

The objective of this task was to reduce the cost of the safe separation device (SSD) spacer and plate assembly. This was accomplished by combining a stamped aluminum top plate, a machined stainless steel rotor shaft, and a zinc die cast spacer into one zinc die casting.

The design configuration of the SSD developed in the Product Improvement Contract DAAK-10-79-C-0169 was used as the baseline for this task. Later, a change in the scope of work incorporated the SSD pinion designed as part of Value Engineering Change Proposal No. 0141-2R1. This required that the pivot hole in the combination SSD spacer and plate be increased from $.034 + .001$ to $.048 + .001$ inch. The design and test parameters used in the development were a maximum of 30,000 g setback and 30,000 RPM spin forces.

TECHNICAL DISCUSSION

The present SSD design uses a die cast spacer, stamped aluminum top plates, and a machined rotor shaft. The rotor shaft is pressed into the rotor to make up the rotor assembly. In the operation of the SSD, the rotor assembly rotates in the pivot holes of the top and bottom plates.

The proposed design combines the SSD top plate, spacer, and rotor shaft into a zinc die cast part. This eliminates a stamping operation and a machining operation, in addition to the assembly operations of these two parts. In this design, the rotor rotates about a stationary shaft, rather than the rotor assembly rotating about the pivot holes.

Since the replacement material for the top plate is weaker than the current aluminum material, changes were made to the combined spacer to make it workable after 30,000 g setback. The combined spacer was made more rigid by making the rotor shaft part of the spacer and by adding material to the spacer in critical areas. In addition to the improved rigidity, the minimum endshake of the three shafts was increased by changing the spacer height from $.300 - .006$ inches to $.302 - .003$. This increases the minimum endshake by $.005$ inch while increasing the maximum endshake by only $.002$ inch.

Before a die for the combined spacer was ordered, prototype SSD assemblies were built and statically load tested with machined zinc top plates and rotor shafts. In this test, a unit was considered to have failed when it would not operate at 1,800 RPM's. The prototype units failed at 5,500 pounds using the old style steel support washer. Present design units with this support washer fail at 5,000 to 5,500 pounds.

With these results a die plus 5,000 parts were ordered from Fisher Gauge. No secondary operations to meet dimensions or for flash removal were required. However, a pad not to exceed $.001$ inches in height, was allowed around the three pivot holes. After the initial sample of parts was received a change of scope of work required the gear and pinion pivot hole be increased from $.034 + .001$ to $.048 + .001$ inch. The die was modified to incorporate this change.

The die cast combined spacers were statically load tested using the new style aluminum support washer. All the units withstood 6,000 pounds before failing to function at 1,800 RPM. Several units functioned at 1,800 RPM after a 7,000 pound load.

TESTING

Air Gun Test

Twenty units, conditioned at -50°F, were air gun tested from 25,930 to 33,750 g's. Six of the SSD's fully armed when spin tested at 1,800 RPM after the test. The rotor partially armed in five units when tested at 1,800 RPM. (An additional drag was put on the rotor in these units from the rotor lock spring which was bent down from the setback force. These partially armed units fully armed when tested at 3,100 RPM.) The remaining units failed to arm when tested at 6,000 RPM because the spin detents were jammed by the indentation of the bottom plate. All but one of the SSD's that failed to arm were in units whose sleeves were broken after the test. Breakage of the sleeve puts an additional load from the timer on the SSD. Results of the test are shown in table 1. There is no explanation for the annealed sleeves.

Out Of Line Detonator Safety Test

Twenty SSD assemblies with the combined spacer were built and tested per MIL-STD-331A, Test 115.1. The top plates of the assemblies had to be modified in order to initiate the detonator in the out of line position. Examination after the test showed no detonation, deformation, burning, charring, scorching, or melting of the lead charge.

Progressive Arming Test

Nineteen SSD assemblies with the die cast combined spacer were tested according to MIL-STD-331A, Test 115.1. The top plates of the assemblies had to be modified in order to initiate the M94 detonator when it is not in the fully armed position. The lead charge detonated when the rotor was in a position of 33.4 degrees prior to the fully armed position. This is after the rotor drops off the gear train. Complete test results are contained in Appendix A. Drawings and tolerance studies are contained in Appendixes B and C, respectively.

Transportation and Vibration Test

Fifteen fuzes with the die cast combined spacer were tested per MIL-STD-331A, Test 104, Procedure 11, Transportation and Vibration Test. After testing, the fuzes were X-rayed and ballistically tested in the 105mm, Zone 7, PD, and successfully passed the nonfunction test (table 2).

Jolt and Jumble Test

Twelve fuzes with the combined spacer were tested per MIL-STD-331A, Test 102.1 and 101.2, Jolt and Jumble Test. All units were examined after testing and found to satisfy the requirements of MIL-F-50983B, Paragraph 4.4.3.1 and MIL-STD-331A, Test 102.1 and 101.2.

Table I. Air gun test results

Test I.

Unit	Setback(g's)	Arming Time at 1800 RPM Before Test(sec)	Arming Time at 1800 RPM After Test (sec)	RPM Unit Armed After Test	Sleeve Condition
1	32,224	1.218	Spin detents jammed	Did not arm at 6000 RPM	Cracked
2	27,303	1.219	1.364	1800	OK
3	30,268	Not recorded	Spin detents jammed	Did not arm at 6000 RPM	Broken
4	32,182	1.228	Partially armed	3100	Broken
5	31,193	1.292	Spin detents jammed	Did not arm at 6000 PRM	Broken
6	27,006	1.285	Partially armed	3100	Broken
7	27,250	1.152	Partially armed	3100	OK
8	27,032	1.185	1.322	1800	OK
9	29,537	1.152	1.268	1800	OK
10	27,742	1.185	Did not arm	3100, did not lock	OK

Test II.

1	32,029	1.119	Did not arm	Partially armed at 6000	Broken
2	33,758	1.263	Spin detents jammed	Did not arm at 6000	Broken
3	26,678	1.152	Partially armed	3100	OK
4	28,360	1.153	1.226	1800	Cracked
5	27,949	1.252	Spin detents jammed	Did not arm at 6000	Broken
6	27,211	1.234	Spin detents jammed	Did not arm at 6000	Broken
7	29,797	1.218	1.267	1800	OK
8	28,790	1.285	Partially armed	3100	OK
9	25,930	1.218	1.236	1800	OK
10	30,024	1.225	Spin detents jammed	Did not arm at 6000	OK

Sequential Rough Handling Test

Sixteen fuzes with the combined spacer were tested per Sequential Rough Handling Test described in Appendix B. After the drop tests, the fuzes were X-rayed and then subjected to ballistic testing. All units were found to be safe to handle and fire after the drop tests. X-rays indicated two of the fuzes had depressed timer setback pins as a result of the sequential rough handling test and therefore could be expected to be duds in ballistics. Ballistic results are shown in table 2. Three of the eight duds were recovered. All three duds were found to be caused by timer failure; two of the three had timer setback pins depressed. No failures were attributable to the redesign of the SSD spacer and top plate.

Ballistic Tests

Test fuzes, built with the combined spacer, and control fuzes were ballistically tested at Yuma Proving Grounds in August, 1983. All test units functioned properly on the targets or ground impact. Round by round data was reported by the U.S. Army Yuma Proving Ground in Firing Report No. 83-PI-0141-15. A summary of the test results is given in table 2.

Ballistic Recovery Test

Thirty inert fuzes with the combined spacer were fired vertically for recovery in the 175mm weapon. Eighteen of the thirty fuzes were recovered, and the SSD was found to have functioned properly in all of them. The remaining fuzes separated from the projectiles and were lost. Test data is shown in table 2.

Table 2. Ballistic results

Test Units

<u>Gun</u>	<u>Zone</u>	<u>Environ- ment (°F)</u>	<u>Setting</u>	<u>Target</u>	<u>Function</u>
155mm, M185	1	-50°	PD	820 ft.	15/15
105mm, M103	7	-50°	PD	820 ft.	15/15
105mm, M103	7	-50°,TV	PD	150 ft.,non-function	0/15
8", M201	9	-50°	PD	200 ft.,non-function	0/9
8", M201	9	-50°	PD	820 ft.	10/10
155mm, 198 system	8	-50°	PD	820 ft.	10/10
155mm, 198 system	8	+145°	PD	Ground	10/10
M549 Projectile					
175mm, M113A1	3	-50°	PD	Vertical recovery	18/18 ²
105mm, M103	7	-50°	50 sec.		06/14 ³
(Sequential)					
(Recovery Test)					

1. One round missed the target and functioned on ground impact.
2. Thirty fuzes were fired, but twelve fuzes separated from the projectiles and were lost.
3. Two test fuzes were set on PD and used for calibration purposes; therefore, they are not part of the test.

Control Units

<u>Gun</u>	<u>Zone</u>	<u>Environ- ment (°F)</u>	<u>Setting</u>	<u>Target</u>	<u>Function</u>
155mm, M185	1	-50°	PD	820 ft.	14/15
105mm, M103	7	-50°	PD	820 ft.	15/15
155mm, 198 system	8	-50°	PD	820 ft.	10/10
155mm, 198 system	8	+145°	PD	Ground	10/10
M549A1 Hera					
8", M201	9	-50°	PD	820 ft.	10/10

TABLE 3. Cost comparison per fuze

Part	Present Design (\$)	Proposed Design (\$)	Savings (\$)
Rotor Shaft	.0193	0.00	.0913
Rotor Assembly	.0337	0.00	.0337
Top Plate, SSD	.1015	0.00	.1015
Rotor, SSD	.0669	.0934	(.0265)
Spacer, SSD	.1710	.2420	(.0710)
Spacer and Plate Assembly	.0874	.0493	.0381
Total:	.5518	.3847	.1671

TABLE 4. Weight comparison

Part	Present Design (lbs)	Proposed Design (lbs)	Net Change (lbs.)
SSD Rotor	.0133	.0128	(.0005)
Rotor Shaft	.0012	.0000	(.0012)
Top Plate	.0086	.0000	(.0086)
SSD Spacer	.0388	.0613	.0225
Total:	.0619	.0741	.0122

COST AND WEIGHT

Cost Comparison

A cost comparison* of the current SSD assembly and the proposed SSD assembly is shown in table 3. The cost of the proposed design is based on a quantity of 500,000 units. These costs do not include tooling, general and administrative expenses, or profit. The projected cost savings is \$0.167 per fuze. Tooling and gage costs were estimated to be \$24,250.

Weight Comparison

A weight comparison of changed parts is given in table 4. The net change to the fuze is an increase of 0.0122 lbs. This increase in weight is considered to be insignificant.

CONCLUSIONS AND RECOMMENDATIONS

The proposed combination safe separation device (SSD) spacer was subjected to the required environmental and ballistic tests with acceptable results. Based on test results and a projected cost savings of \$0.167 per fuze, this design has been shown to be a feasible replacement for the present SSD spacer. However, using the combination SSD spacer with the M577A1, the inertial PD fuzes, requires modification to the combined spacer die. Since the proposed design has not been tested with the M577A1 fuze, environmental and ballistic testing of the proposed design with the M577A1 fuze should be performed.

* 1983 dollars.

APPENDIX A
TEST RESULTS

TEST RESULTS FOR PROGRESSIVE ARMING TEST (MIL-STD-331A)

A total of 19 SSD assemblies were tested at seven positions between the safe and armed position of the rotor. These are:

1. Safe position 100° before armed position.
2. 83.5° before armed position.
3. 66.8° before armed position.
4. 50.1° before armed position. (Approximately the position at which
5. 33.4° before armed position. the rotor drops off the verge
6. 16.7° before armed position. escapement)
7. Armed position.

The first trial of the test was performed with the rotor in the safe position. Following the test procedure described earlier, the rotor was then moved closer to the armed position by increments of 16.7° until the lead charge was detonated. The rotor position at which the lead charge began to detonate was 33.4°. The position of the rotor was alternated between 50.1° and 33.4° five times to assure that the results were repeatable. Each time, the detonation occurred with the rotor being at a position of 33.4° before the armed position.

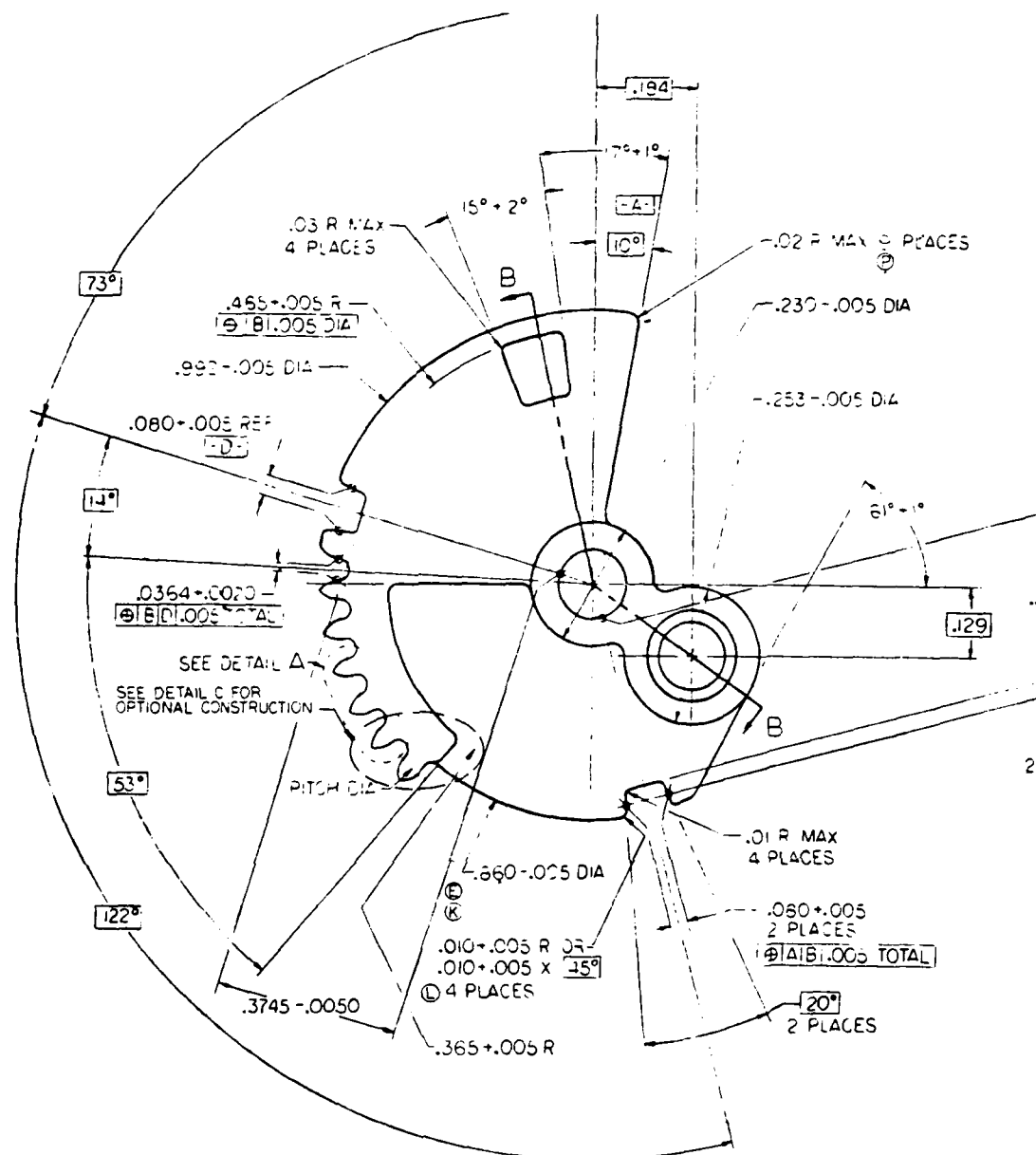
The lead charge was detonated when the rotor was at positions 33.4°, 16.7° and at the armed position. The lead charge failed to detonate when the rotor was placed at a position of 50.1°, 66.8°, 83.5° and the safe position.

TEST RESULTS FOR SEQUENTIAL ROUGH HANDLING (MTP-4-2-602; MIL-STD-331A)

Sixteen fuzes (16) were subjected to the sequential rough handling test. The fuzes were visually examined according to the test procedure and found to have no damage that would affect safety. The units were then x-rayed. The setback pin in the timer in two fuzes was not in the upright position. One of these fuzes had been tested in all five orientations and the other one in the nose down position in the five-foot drop. This condition could result in a fuze dud, but it does not affect the safety of the fuze. These 16 fuzes have been shipped for ballistic testing in the 105mm, M103 gun with a Zone 7 charge, set on 50 seconds.

APPENDIX B

DRAWINGS

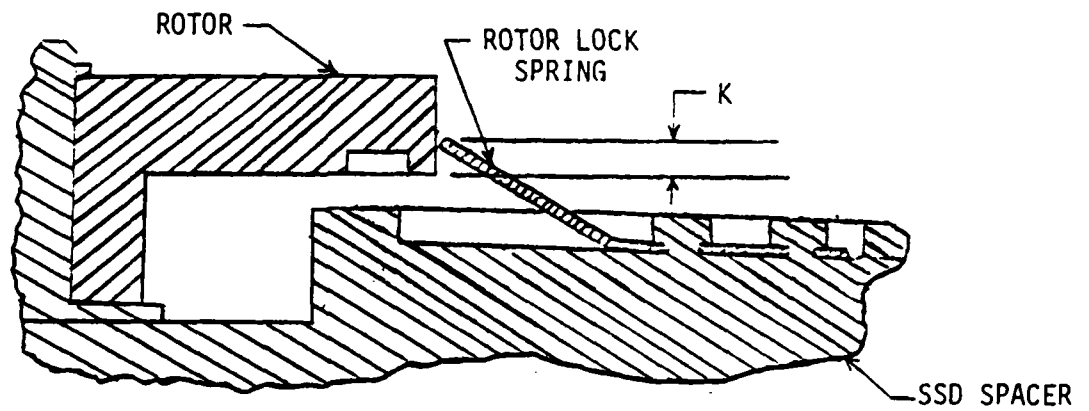


NOTES:-

- 1 - SPEC MIL-A-2550 APPLIES.
- 2 - MATERIAL:- ZINC ALLOY DIE CASTING ALLOY A640A, ASTM B86.
- 3 - UNLESS OTHERWISE SPECIFIED FILLETS ARE TO BE $.005 \text{ R MAX}$ AND CORNERS ARE TO BE $.005 \text{ R MAX}$ OR $.005 \text{ MAX}$.
- 4 - 125° ALL OVER, EXCEPT AS NOTED.
- 5 - SURFACE FINISH INHERENT WITH MANUFACTURING PROCESS PERMITTED FOR TOOTH AREA BETWEEN $.980 \text{ DIA}$ AND $.81 \text{ DIA}$.
- 6 - NO POROSITY SHALL BE VISIBLE ON THE ENTIRE SURFACE AREA.
- 7 - DRAFT PERMITTED WITHIN TOLERANCE.
- 8 - PROTECTIVE FINISH:- FINISH 6.1.2 OF MIL-STD-171, EXCEPT PART SHALL BE EXPOSED TO A SALT SPRAY FOR A MINIM 24 HOURS IN LIEU OF 96 HOURS PER PARA 4.4.3 OF MIL-T-12879.
- 9 - ROTOR TEETH MUST WITHSTAND A TORQUE OF 90 IN LBS.

APPENDIX C
TOLERANCE STUDIES

ENGAGEMENT OF ROTOR LOCK SPRING IN THE SSD ROTOR

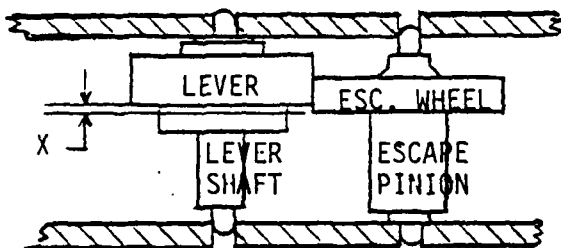


<u>PART</u>		<u>+</u>	<u>-</u>
Spring	(-) .088	- .026	
Spacer	.195	.005	
Rotor	(-) .006	- .001	
Rotor	(-) .152	- .005	
		- .051	+ .037
K =		- .014	/ - .051 ↑+↓-
negative is engagement distance			

TOLERANCE STUDY

Tolerance study of misengagement of the Escape Wheel with the SSD Lever when:

SSD Lever is up and
Escape Wheel is down

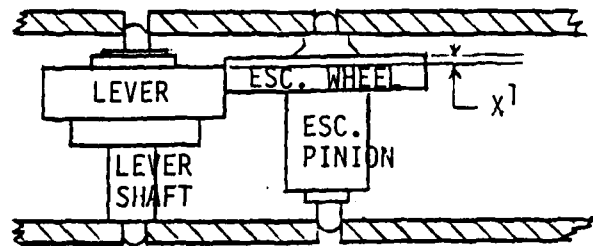


PART		+	-
Gap	(-).000		+.001
Lever Shaft	.069		.002
Spacer	(-).302	.003	
Escape Pinion	.291		.002
Escape Pinion	(-).053		+.002
Gap	.000	.002	
	.005	+.005	-.007

$$x = .010 / -.002 \uparrow + \downarrow -$$

negative is misengagement

SSD Lever is down and
Escape Wheel is up

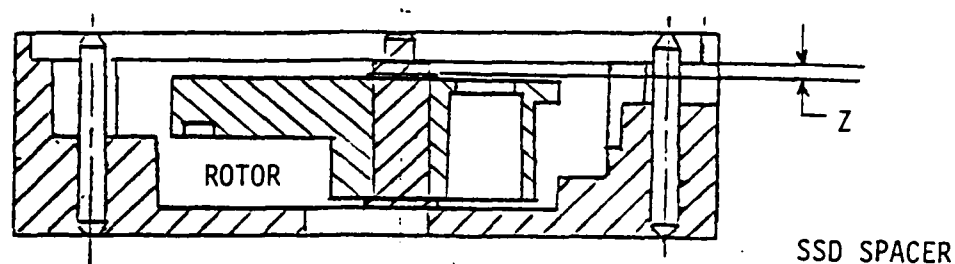


PART		+	-
Escape Wheel	(-).020	-.001	+.001
Gap	(-).000		+.002
Escape Pinion	.053	.002	
Spacer	(-).302	-.003	
Lever Shaft	.291		.002
Lever Shaft	(-).069	-.002	
Gap	.000	.001	
Lever	.046	.001	.001
	-.001	+.010	-.006

$$x^1 = .009 / -.007 \uparrow + \downarrow -$$

positive is misengagement

Tolerance Study Of The Endshake Clearance Between The SSD Rotor And The Spacer



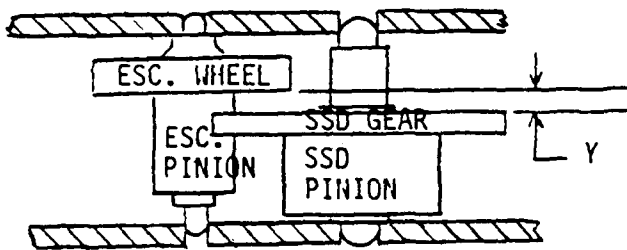
PART		+	-
Spacer	.302		.003
Spacer	(-) .020	-.002	
Rotor	(-) .270	-.005	
Rotor	(-) .006	-.001	
	.006	+.008	-.003

$$z = .014 / .003 \quad \uparrow + \downarrow -$$

Positive is clearance

Tolerance study of clearance between Escape Wheel and SSD Gear when:

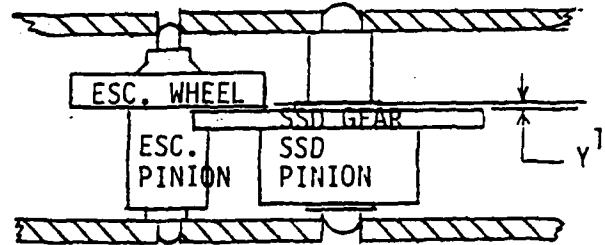
Escape Wheel and Pinion
Ass'y is up and SSD Gear
and Pinion Ass'y is down



PART		+	-
Escape Pinion	.053	.002	
Spacer	(-).302	-.003	
Gear Pinion	.291		.002
Gear Pinion	(-).108		+.002
Gap	.000	.002	
Gear	.032		.002
	- .034	+.007	-.006

$Y = -.027/-.040 \uparrow \downarrow$
Negative is clearance

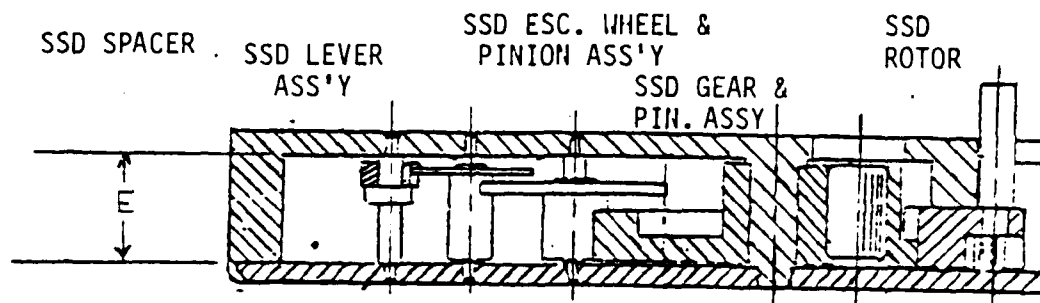
SSD Gear and Pinion Ass'y is
up and Escape Wheel and Pinion
Ass'y is down



PART		+	-
Gear	(-).032	-.002	
Gap	.000	.002	
Gear Pinion	.108	.002	
Gear Pinion	(-).302		.003
Spacer	.291		.002
Escape Pinion	(-).053		+.002
	.012	+.006	-.007

$Y1 = .018/.005 \uparrow \downarrow$
Positive is clearance

Tolerance Study Of The Endshake Clearance For SSD Assemblies In The SSD Spacer



PART		+	-
Spacer	.302		.003
Pinions (-)	.291	-.002	
	.011	+.002	-.003

$$E = .013 / .008 \quad \uparrow \downarrow -$$

Positive is clearance

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